

Comparison of Applied vs. Local Strains in Human Mesenchymal Stem Cell Seeded 3D Collagen Gels

Wayne Pfeiler

Dr. Ruwan Sumanasinghe

Dr. Elizabeth Loba

March 8, 2008



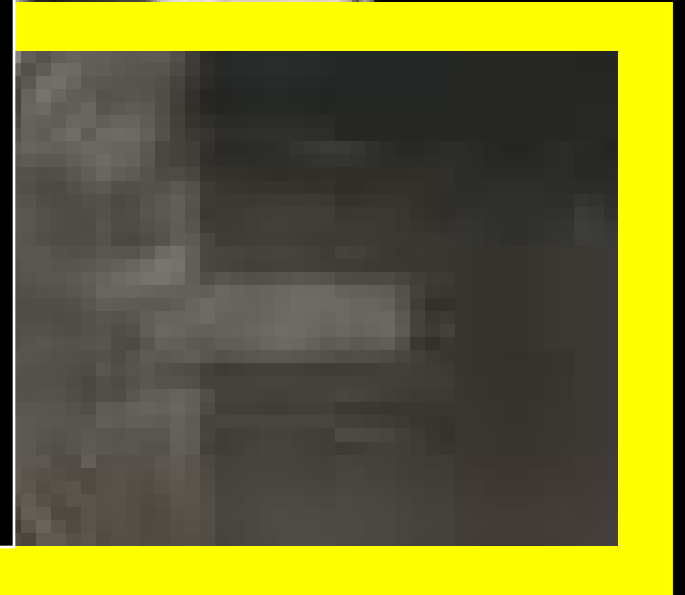
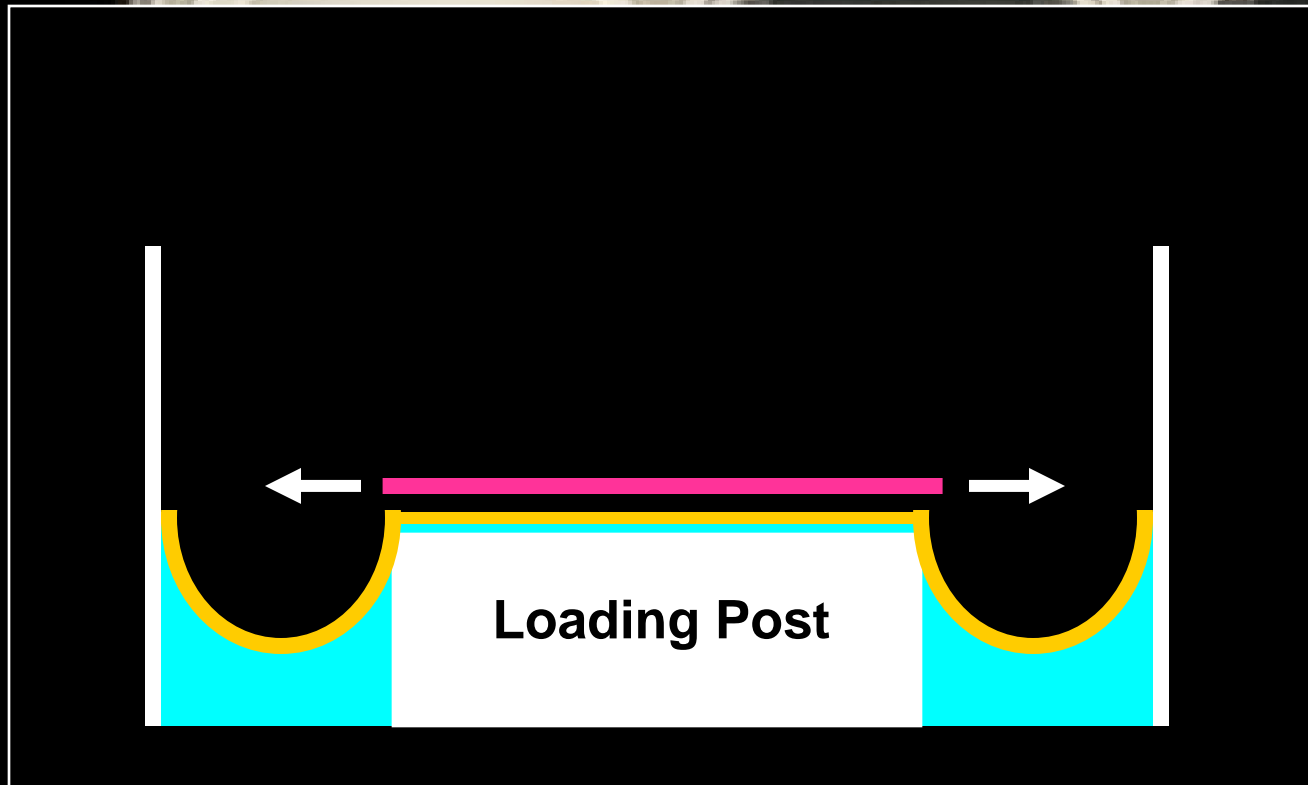
Previous Work

- hMSC-seeded 3D collagen gels
 - Strain induces osteogenic differentiation
 - Cells modify surrounding matrix
- Questions raised

Sumanasinghe, 2006 Tissue Eng. 2006 12(12):3459-65.

Sumanasinghe, 2008 J Biomed Mater Res A. (In Press)

Background: Flexcell TissueTrain



Goals

- Use finite element models to determine local strains experienced by hMSCs seeded within collagen matrices in the TissueTrain bioreactor.
- Use results to explain behavior of cells that has been observed.

Required Information

Geometry

Material Properties

Bioreactor



Size of TT Wells
and Anchors

Anchor Stiffness
Poisson's Ratio

Collagen Matrices

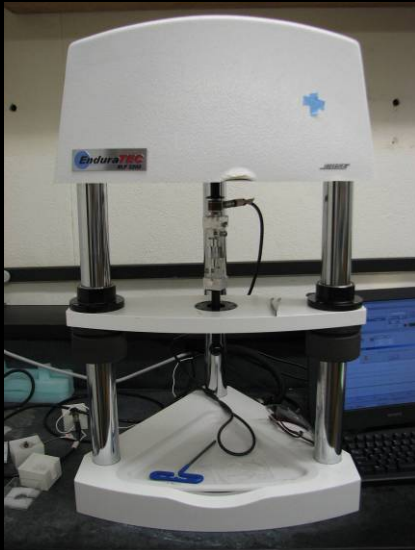
Matrix Dimensions

Matrix Stiffness
Poisson's Ratio



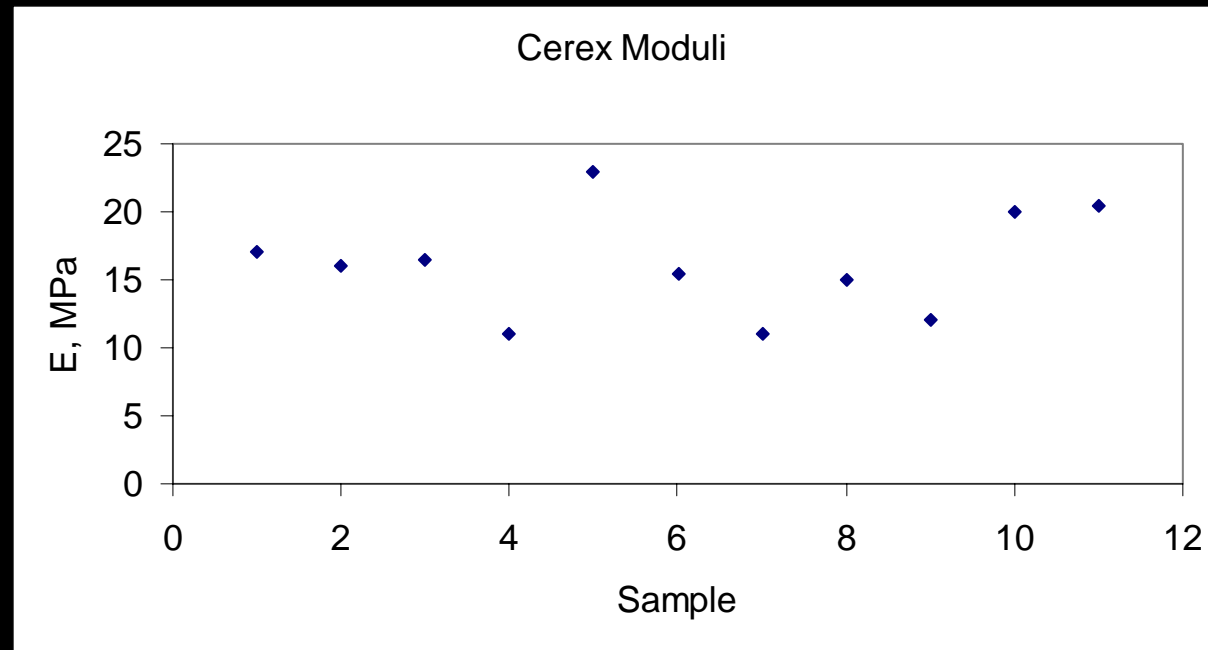
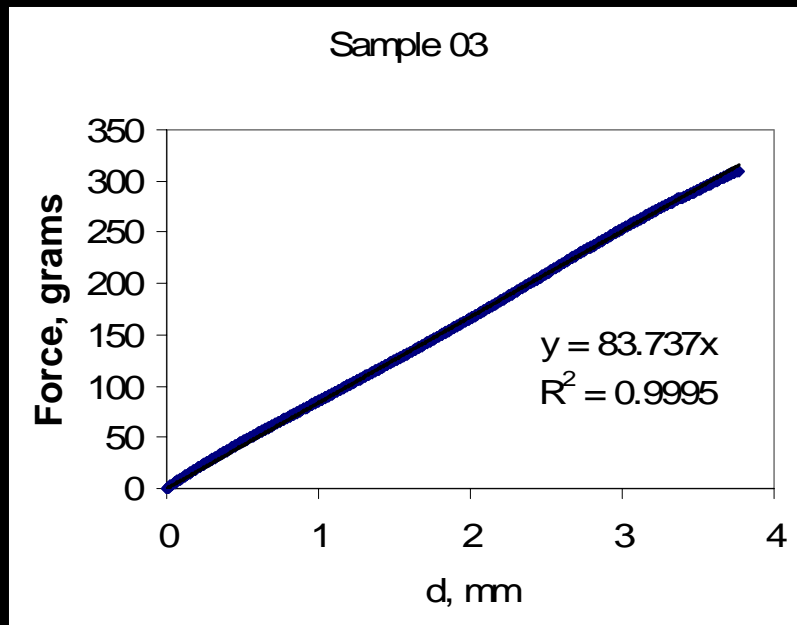
Testing Cerex Nonwoven Anchors

- Tensile testing, Enduratec ELF 3200
 - 500g LC, 2% ϵ /sec



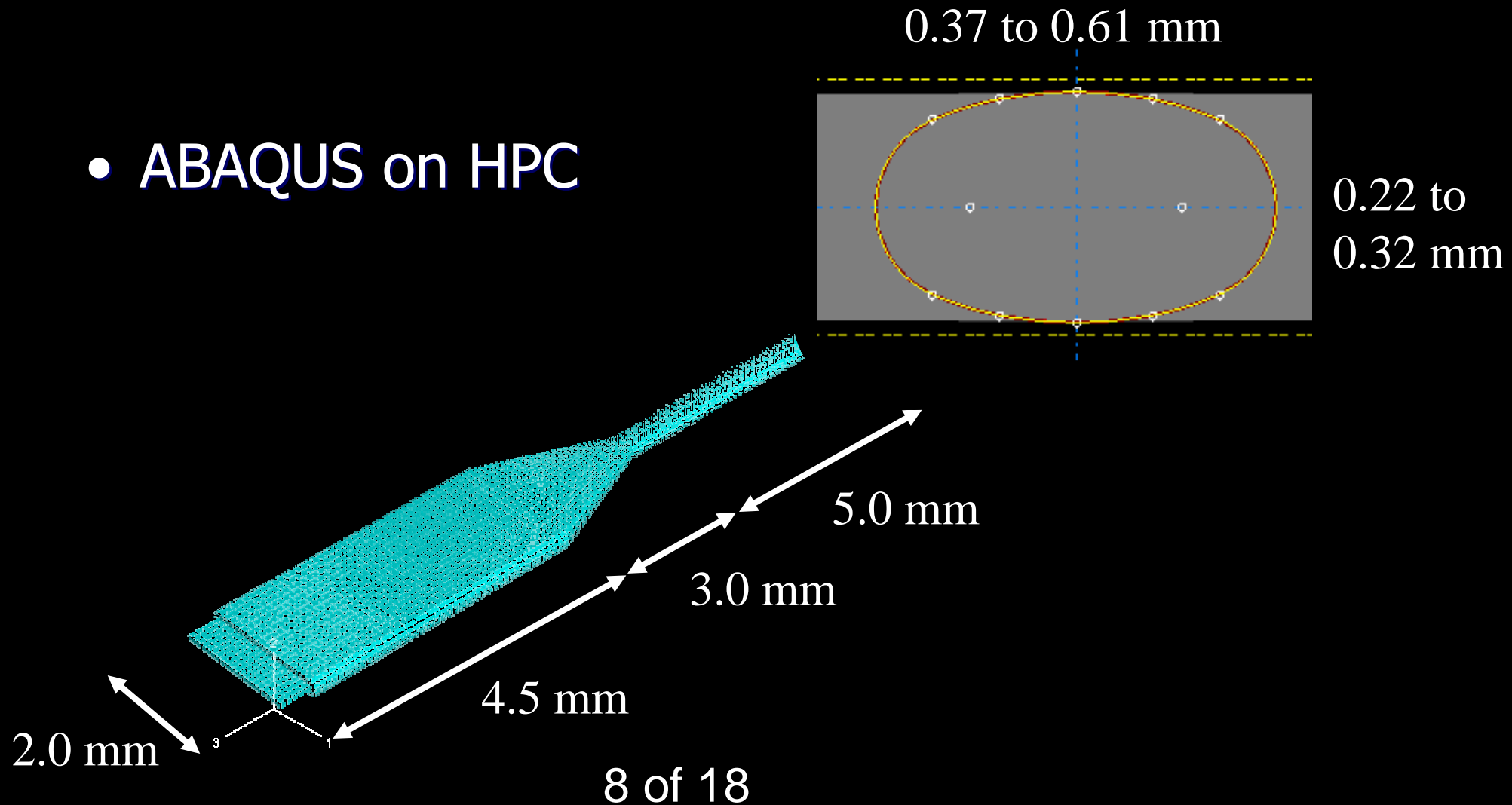
Cerex Testing Results

- Average elastic modulus: 16.3 MPa, SD=3.6

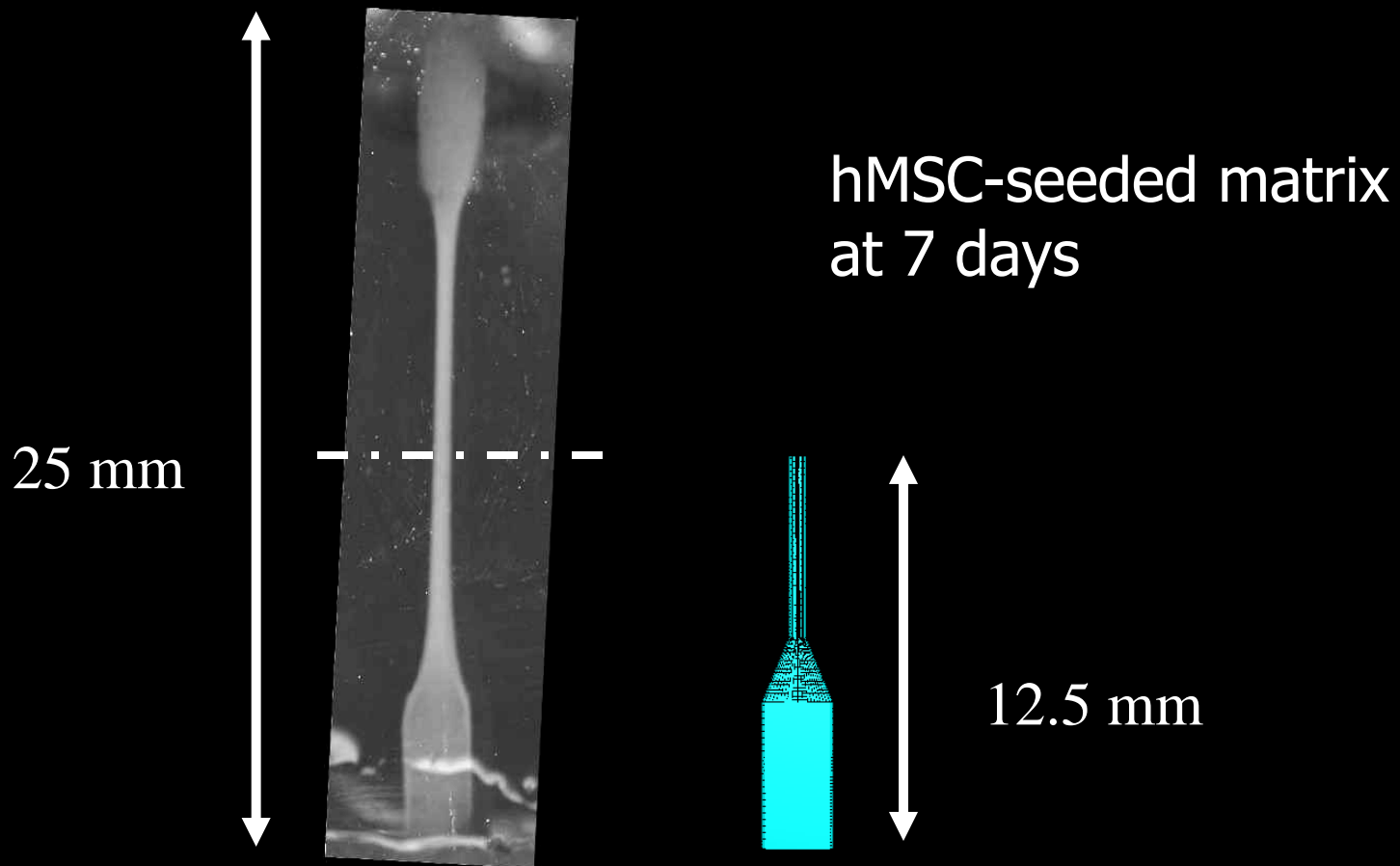


Finite Element Models

- ABAQUS on HPC



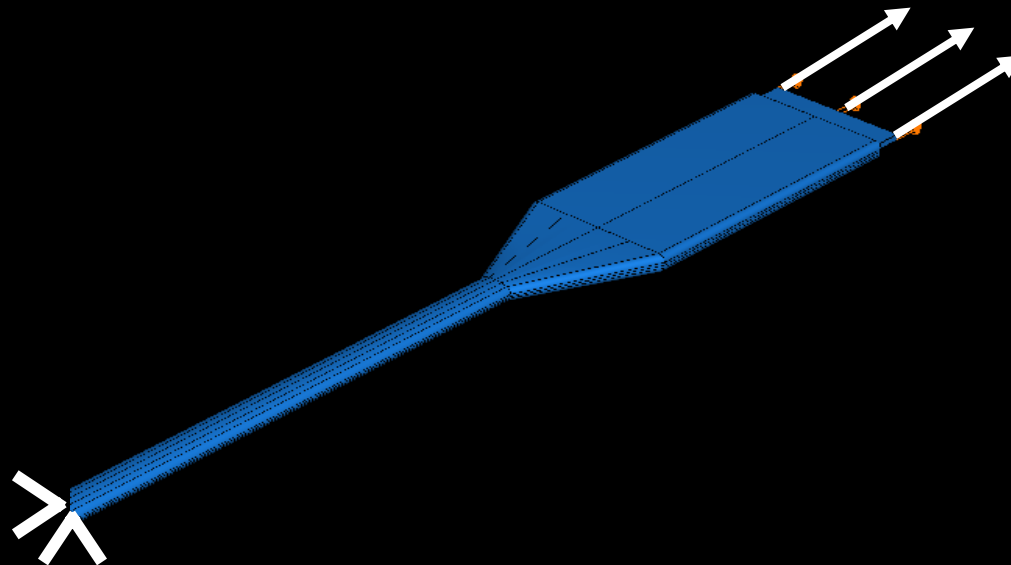
Comparison with Matrix



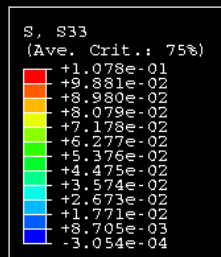
Applying Loads

Apply positive 10% or 12% strain to one end

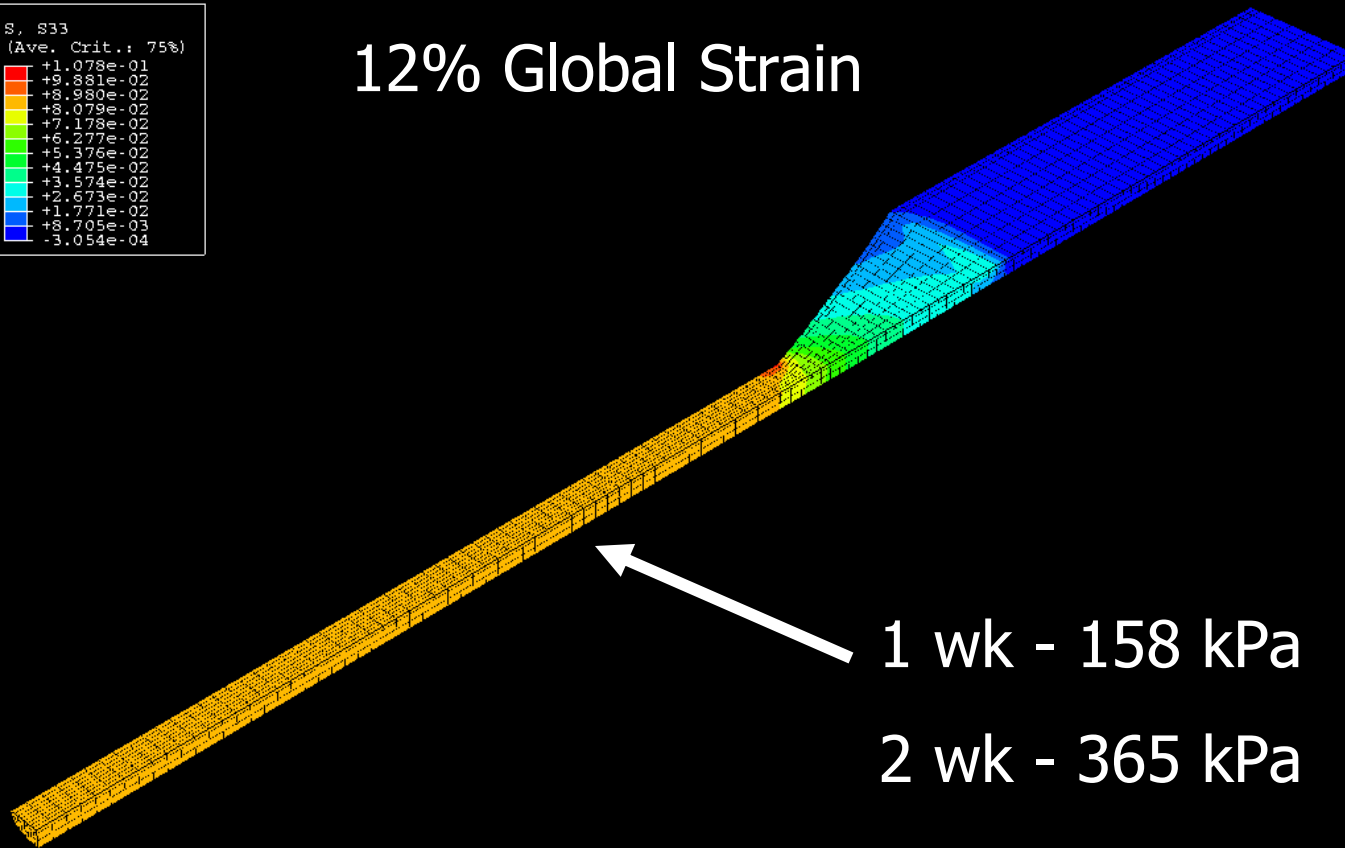
Constrain axial
displacement



Axial Stress



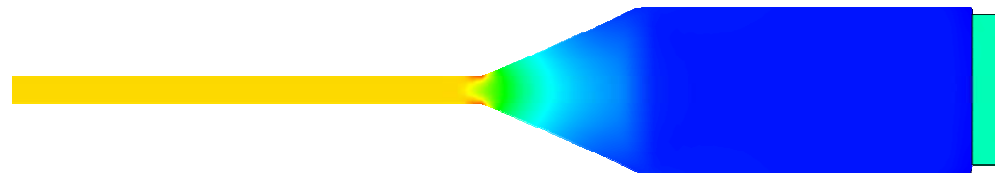
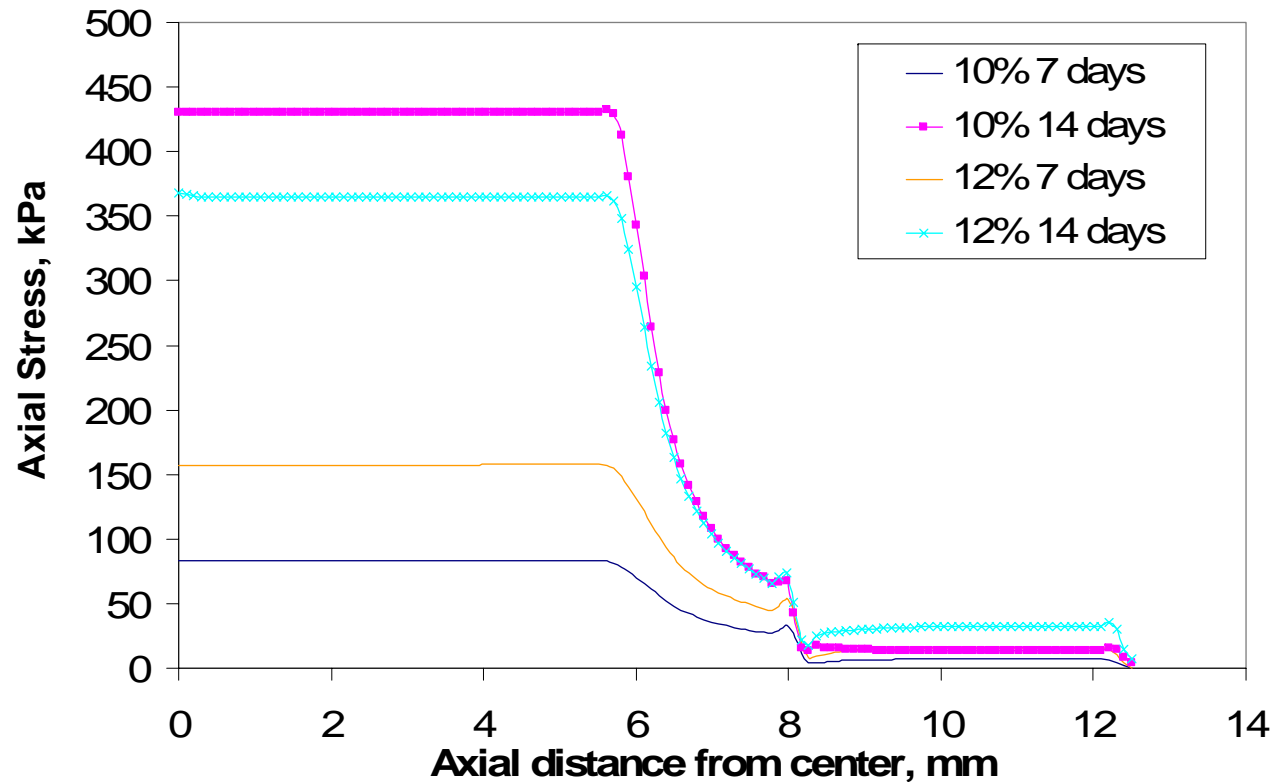
12% Global Strain



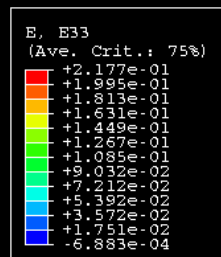
1 wk - 158 kPa

2 wk - 365 kPa

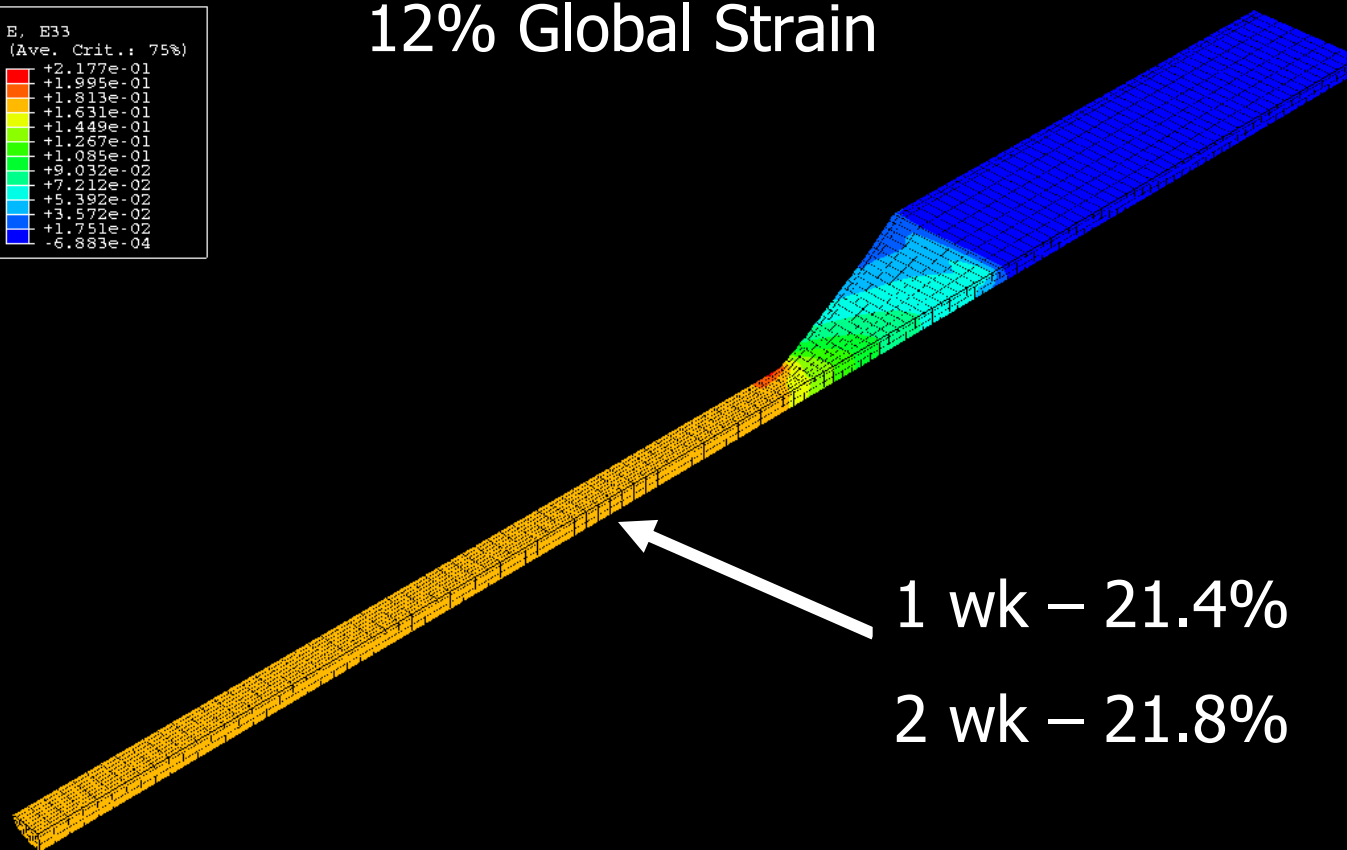
Axial Stress Through Matrices



Axial Strain



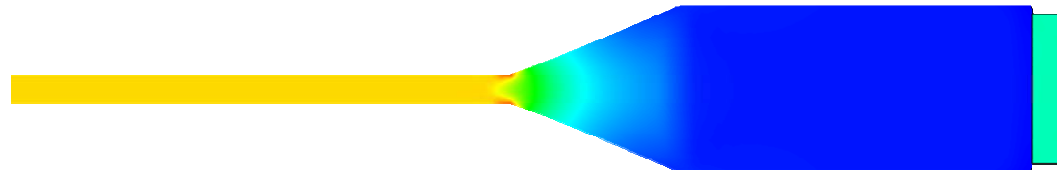
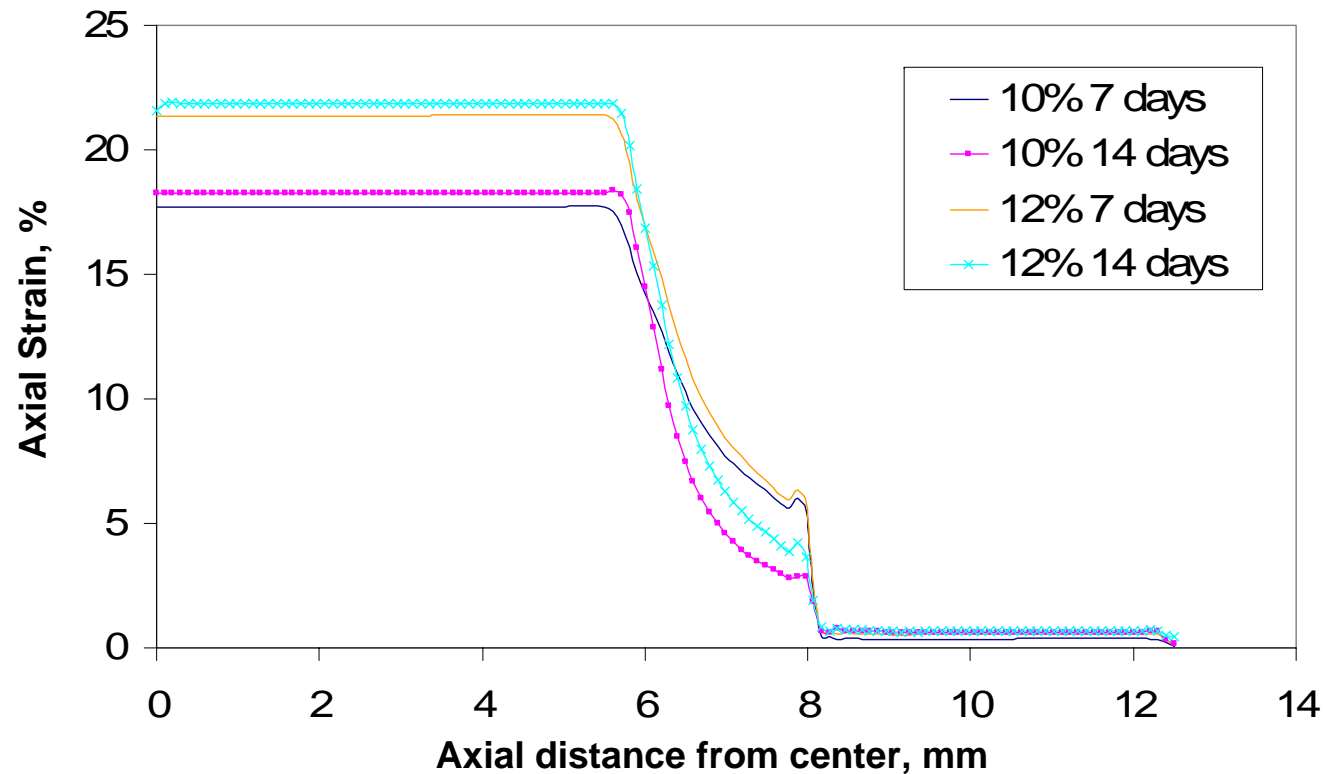
12% Global Strain



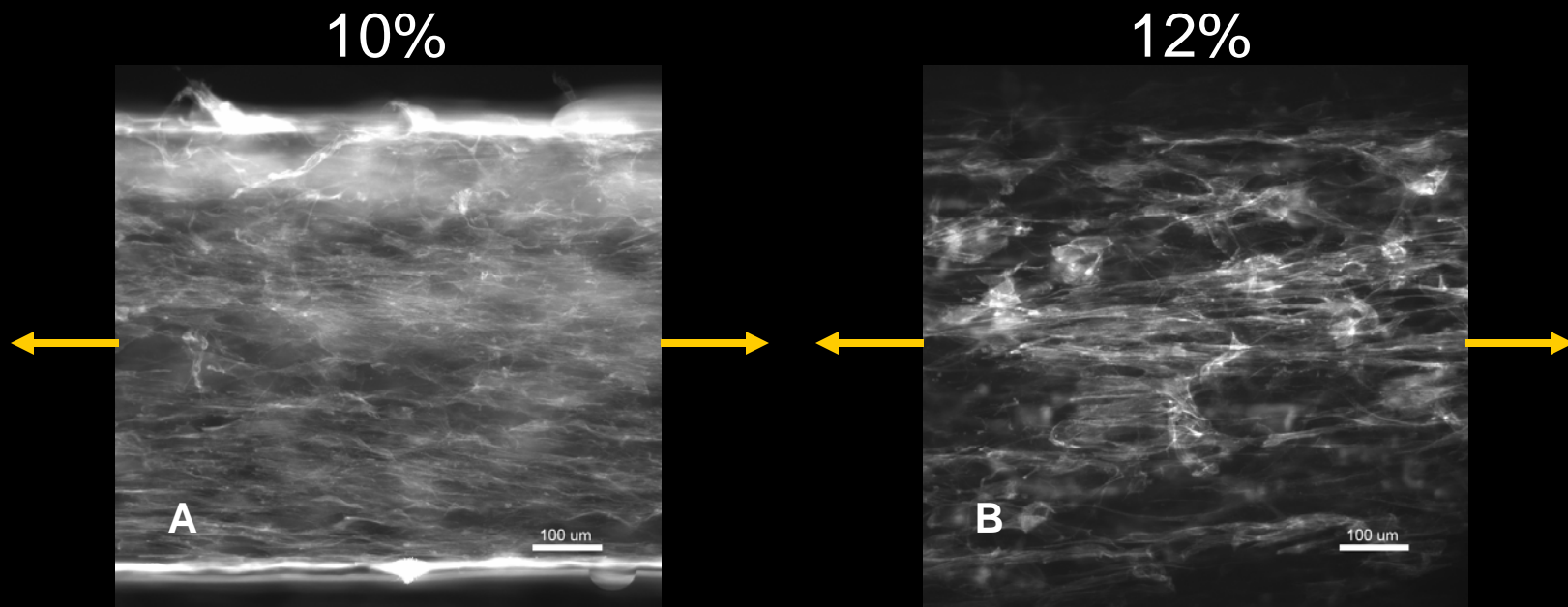
1 wk – 21.4%

2 wk – 21.8%

Axial Strain Through Matrices



Actin Cytoskeleton Alignment



Discussion

- Local strains experienced by cells were up to 83% greater than global applied strains
- Local stresses increased with time in culture
- Actin cytoskeleton appears less organized at 12% global strain

Acknowledgements

- Dr. Albert Banes
- Flexcell Int.
- Dr Susan Bernacki
- NIH STTR Grant # 1R41AR052268-01A1 (AJB, EGL)
- NC Biotechnology Center MRG (EGL)

Thank you

Questions?